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### Statistics and Its Methods

*Economic Cycles: Their Law and Cause.* By HENRY LUDWELL MOORE. (New York: The Macmillan Company. 1914. Pp. viii, 149. \$2.00.)

*Economic Cycles: Their Law and Cause* is a carefully worked out and well-written study of the statistics of rainfall, crop yields per acre and total production, iron production, and general prices, developed by the mathematical methods of curve-fitting and correlation. The conclusion of the author is this:

The weather conditions represented by the rainfall in the central part of the United States, and probably in other continental areas, pass through cycles of approximately thirty-three and eight years in duration, causing like cycles in the yield per acre of the crops; these cycles of crops constitute the natural, material current which drags upon its surface the lagging, rhythmically changing values and prices with which the economist is more immediately concerned (p. 149).

This conclusion is, apparently, not in harmony with the conclusions of recent writers on business cycles as to the role played by crops in causing prosperity and depression. Veblen, for instance, says in *The Theory of Business Enterprise* that "the true, or what may be called the normal, crises, depressions, and exaltations in the business world are not the result of accidents, such as the failure of a crop. They come in the regular course of business" (p. 183). Mitchell holds that good or bad crops are the most important of numerous "extraneous factors" that cause "divergences among business cycles" which are business phenomena caused by variations in profits.<sup>1</sup>

In Professor Moore's statistical methods and reasoning the reviewer finds no important defect. The author finds cycles of thirty-three and eight years in rainfall and crops. The method of attaining this result is in accord with recognized mathematical processes which allow the data, rather than the pre-conceived notions of the investigator to mould the conclusion. Given the cycles in crops and rainfall, the remainder of the argument depends upon the high degree of correlation found (by means of Pearson's coefficient of correlation) among various statistical series beginning with annual rainfall and yields per acre of important crops and ending with pig-iron production and general prices, the last-named series being taken as business barometers. In the opinion of the

<sup>1</sup> *Business Cycles*, pp. 582, 239.

reviewer the high correlation found ( $r$  being upwards of 0.60 in most cases) warrants Professor Moore's conclusions. Outside considerations and the sequence of fluctuations rather than the coefficient itself, of course constitute the reasons for specifying rainfall as cause, and crop yields, iron production, and general prices as effects.

The argument runs as follows:

1. The rainfall data of the Ohio Valley for the period 1839-1910 is well described by a multiple sine function (five terms of Fourier's series) showing cycles of thirty-three and eight years and their semi-harmonics.

2. The curve thus found fits the rainfall data of Illinois for the period 1870-1910. The coefficient of correlation ( $r$ ) for the two series of annual rainfall is 0.60.

3. The yields per acre (secular trend eliminated) of corn, oats, hay, and potatoes in Illinois constituting 96 per cent of the crop value in 1912, are highly correlated with the rainfall of the "critical period" of the crop in question. The coefficients are, respectively, 0.589, 0.290, 0.620, and 0.666.

4. The combined crop indices fluctuate with the mean effective rainfall of the critical periods,  $r = 0.584$ .

5. The percentage price changes from year to year of the four representative crops vary inversely with the percentage changes in yields per acre, the coefficients being, respectively, -0.815, -0.656, -0.718, and -0.873.

6. The fluctuations in the yield per acre of the four representative crops in the United States correspond to the fluctuations in Illinois, the coefficients for corresponding annual differences ranging from 0.745 to 0.855. Likewise, the yield of the four crops in the United States is representative of the yield of nine crops, including all the leading cereals, hay, potatoes, and cotton—indices for the groups of four and nine crops giving a coefficient of 0.960.

7. The cycles of yield per acre of nine crops precede similar cycles in pig-iron production by two years. The coefficients obtained by pairing yield indices with iron production of the same year and lags of one, two, three, and four years are, respectively, 0.625, 0.719, 0.718, 0.697, and 0.572.

8. The cycles of yield per acre of nine crops precede similar cycles in general prices (Aldrich and Labor Bureau indices) by four years. The coefficients obtained by pairing yield indices with

general prices three, four, and five years later are, respectively, 0.786, 0.800, and 0.710. This completes the chain of reasoning summarized by Professor Moore in the quotation made at the beginning of this review.

The author's conclusions are an extension and application of those of Mr. R. H. Hooper<sup>2</sup> and Professor J. Warren Smith, sectional director of the United States Weather Bureau. However, he refers to neither of the writers named. Professor Smith stated in the 1903 *Year Book of the Department of Agriculture*: "If one knows the precipitation during the month of July over the great corn-producing district he can estimate the yield of the season very closely." Professor Smith based this statement upon a study covering the eight leading corn states for the period 1888-1902; average yield per acre was compared graphically with the average precipitation in June, July, and August. In the *Monthly Weather Bulletin* for February, 1914, he continued the study, this time using the Pearsonian coefficient. He found that for eight corn states during the period 1888-1912 the yield of corn per acre and the rainfall in July gave a coefficient of 0.78.

Professor Moore has found the demand curves for each of the four representative crops and for pig-iron. The demand curves of the crops slope downward toward the right indicating that "the amount demanded increases with a fall in price and diminishes with a rise in price." In contrast to agricultural products, the demand curve for pig-iron slopes upward toward the right. The reviewer has found results that confirm those of Professor Moore.<sup>3</sup>

The series of indices of crop-yield, pig-iron production, and general prices, used by the author in getting the correlation coefficients quoted in 7 and 8 above are not annual figures but three-year averages, e.g., the crop yield for 1895 is the average for 1894-5-6. *Cumulative* effects are thus measured. The reviewer has found that *annual* yields correlated with *annual* general prices four years later give a coefficient of 0.599, a lower coefficient than the one obtained by using three year averages, and that four-year average yields correlated with Moore's three-year average general prices with a lag of three and a half years give a coefficient of

<sup>2</sup> See "Correlation of the Weather and the Crops," *Journal of the Royal Statistical Society*, vol. 70 (1907), p. 1.

<sup>3</sup> See *Quarterly Publications of the American Statistical Association*, vol. XII (Dec., 1910), p. 314.

0.842, a higher coefficient than the one obtained by Moore, using three-years averages in both cases.

It seems to the reviewer that Professor Moore's "law of economic cycles" is not conflicting with that of Professor Mitchell. The latter gives an excellent account of what takes place in the business world during the four years of prosperity following bumper crops and the four years of depression following scant crops. Moore tells why the chain of events starts; Mitchell describes the sequence of events resulting.

WARREN M. PERSONS.

*Colorado College.*

*Statistical Atlas of the United States.* Prepared under the supervision of CHARLES S. SLOANE, Geographer of the Census. (Washington: Department of Commerce. Bureau of the Census. 1914. Pp. 90; plates, 503.)

This volume is the fourth in the series of statistical atlases published by the Bureau of the Census. To Francis A. Walker credit is due for the first use of the graphic method in census volumes. Colored maps were employed in the preparation of certain of the ninth census reports in 1871, and appear to have made a favorable impression at once. The Secretary of the Interior, in making his annual report for the following year, urged the compilation of a statistical atlas. Congress immediately voted the necessary appropriation and a large folio volume was issued in 1874.<sup>1</sup>

Though graphic illustration was greatly extended in the census of 1880, no atlas was published. In considerable measure the succession was kept intact, however, by the volume prepared under Mr. Henry Gannett's direction and published by Charles Scribner's Sons, *Scribner's Statistical Atlas* (New York, 1883). In connection with the eleventh census the government returned to the task and issued its second atlas, in large folio size like the first. Mr. Gannett, as Geographer of the Census, had charge of the preparation of the volume, as also of the atlas of 1903, which was thrown into the much more convenient quarto form. This last issue continues the quarto form, but it reflects many of the changes that have marked the organization and work of the Bureau of the Census during the past ten years. The atlas of the twelfth census

<sup>1</sup>This first statistical atlas was published in a limited edition and is not commonly available.